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Claims

[c1] An ultrasonic transducer assembly for helping monitor a fluid flowing through a duct, said ultrasonic transducer assembly comprising:
a piezoelectric transducer element having a first contact surface electroplated with a first metallic film layer and an opposite second contact surface electroplated with a second metallic film layer;
a housing, configured on and at least partially conterminous with the outer surface of said duct, having a chamber in which said piezoelectric transducer element is situated and thereby substantially enclosed; and
means for conducting electrical signals between said electroplated first contact surface of said piezoelectric transducer element and the outside of said housing;
wherein said electroplated second contact surface of said piezoelectric transducer element is solder-mounted within said housing such that said piezoelectric transducer element is thereby coupled to said outer surface of said duct in a substantially conterminous fashion.

[c2] An ultrasonic transducer assembly according to claim 1, wherein said ultrasonic transducer assembly is utile for

helping monitor the temperature and the flow rate of said fluid flowing through said duct.

[c3] An ultrasonic transducer assembly according to claim 1, wherein said fluid is a constituent for a propellant mixture.

[c4] An ultrasonic transducer assembly according to claim 1, wherein said fluid is selected from the group consisting of liquid oxygen and liquid hydrogen.

[c5] An ultrasonic transducer assembly according to claim 1, wherein said duct comprises metal.

[c6] An ultrasonic transducer assembly according to claim 1, wherein said duct is physically associated with a thrusting engine onboard a rocket.

[c7] An ultrasonic transducer assembly according to claim 1, wherein said piezoelectric transducer element is a ceramic crystal wafer.

[c8] An ultrasonic transducer assembly according to claim 7, wherein said ceramic crystal wafer has a lead zirconate titanate composition.

[c9] An ultrasonic transducer assembly according to claim 1, wherein each of said first metallic film layer and said second metallic film layer of said piezoelectric trans-

ducer element comprises at least one metal selected from the group consisting of gold, indium, and silver.

[c10] An ultrasonic transducer assembly according to claim 1, wherein each of said first metallic film layer and said second metallic film layer of said piezoelectric transducer element has a thickness selected from within a range of about 4 mils to 6 mils.

[c11] An ultrasonic transducer assembly according to claim 1, wherein said housing comprises a plurality of pieces attached together and collectively situated on said outer surface of said duct.

[c12] An ultrasonic transducer assembly according to claim 11, wherein at least one of said pieces of said housing comprises a constituent material selected from the group consisting of a ceramic, a metal, and a plastic.

[c13] An ultrasonic transducer assembly according to claim 11, wherein one of said pieces of said housing is a removable cover plate for providing open access to said chamber within said housing.

[c14] An ultrasonic transducer assembly according to claim 13, wherein said removable cover plate has a hole defined therethrough for physically accommodating said electrical signals conducting means.

[c15] An ultrasonic transducer assembly according to claim 11, wherein at least one of said pieces of said housing has an external surface at least partially electroplated with an external metallic film layer, and at least part of said electroplated external surface is coupled to said outer surface of said duct in a substantially conterminous fashion such that said piezoelectric transducer element is thereby coupled to said outer surface of said duct in a substantially conterminous fashion.

[c16] An ultrasonic transducer assembly according to claim 15, wherein said external metallic film layer comprises at least one metal selected from the group consisting of gold, indium, and silver.

[c17] An ultrasonic transducer assembly according to claim 15, wherein said external metallic film layer has a thickness selected from within a range of about 4 mils to 6 mils.

[c18] An ultrasonic transducer assembly according to claim 11, wherein at least one of said pieces of said housing is integral with said outer surface of said duct.

[c19] An ultrasonic transducer assembly according to claim 1, wherein said housing has an internal surface lining said chamber and at least partially electroplated with an in-

ternal metallic film layer.

[c20] An ultrasonic transducer assembly according to claim 19, wherein said internal metallic film layer of said housing comprises at least one metal selected from the group consisting of gold, indium, and silver.

[c21] An ultrasonic transducer assembly according to claim 19, wherein said internal metallic film layer of said housing has a thickness selected from within a range of about 4 mils to 6 mils.

[c22] An ultrasonic transducer assembly according to claim 1, wherein said electrical signals conducting means comprises an interconnected plurality of electrically conductive elements in which at least one of said electrically conductive elements is selected from the group consisting of an anechoic cone, a coaxial cable, an electrical connector, a metallic lug, and a wire.

[c23] An ultrasonic transducer assembly according to claim 22, wherein said anechoic cone has an outside surface at least partially electroplated with an outside metallic film layer, and said electroplated outside surface of said anechoic cone is solder-mounted on said electroplated first contact surface of said piezoelectric transducer element.

[c24] An ultrasonic transducer assembly according to claim

23, wherein said outside metallic film layer of said anechoic cone comprises at least one metal selected from the group consisting of gold, indium, and silver.

[c25] An ultrasonic transducer assembly according to claim 23, wherein said outside metallic film layer of said anechoic cone has a thickness selected from within a range of about 4 mils to 6 mils.

[c26] An ultrasonic transducer assembly according to claim 23, wherein said piezoelectric transducer element has an inherently associated Curie temperature, and said electroplated outside surface of said anechoic cone is solder-mounted on said electroplated first contact surface of said piezoelectric transducer element with a solder comprising an indium alloy and at a soldering temperature less than said Curie temperature.

[c27] An ultrasonic transducer assembly according to claim 22, wherein said wire comprises a plurality of electrically conductive strands that are substantially held together via a means selected from the group consisting of braiding, interweaving, knotting, plaiting, stranding, twisting, tying, and wrapping to thereby render said wire characteristically flexible and substantially able to withstand vibration.

[c28] An ultrasonic transducer assembly according to claim 1, wherein said piezoelectric transducer element has an inherently associated Curie temperature, and said electroplated second contact surface of said piezoelectric transducer element is solder-mounted within said housing with a solder comprising an indium alloy and at a soldering temperature less than said Curie temperature.

[c29] An ultrasonic transducer assembly for helping monitor a fluid flowing through a duct, said ultrasonic transducer assembly comprising:
a piezoelectric transducer element having a first contact surface electroplated with a first metallic film layer, an opposite second contact surface electroplated with a second metallic film layer, and an inherently associated Curie temperature;
a housing, configured on and at least partially coterminous with the outer surface of said duct, having a chamber in which said piezoelectric transducer element is situated and thereby substantially enclosed; and
means for conducting electrical signals between said electroplated first contact surface of said piezoelectric transducer element and the outside of said housing;
wherein each of said first metallic film layer and said second metallic film layer of said piezoelectric transducer element comprises at least one metal selected

from the group consisting of gold, indium, and silver; and

wherein said electroplated second contact surface of said piezoelectric transducer element is solder-mounted within said housing with a solder comprising an indium alloy, at a soldering temperature less than said Curie temperature, and such that said piezoelectric transducer element is thereby coupled to said outer surface of said duct in a substantially conterminous fashion.

[c30] A process for fabricating an ultrasonic transducer assembly utile for helping monitor a fluid flowing through a duct, said fabrication process comprising the steps of:

(a)electroplating a first metallic film layer on a first contact surface of a piezoelectric transducer element and electroplating a second metallic film layer on an opposite second contact surface of said piezoelectric transducer element;

(b)situating said piezoelectric transducer element in a chamber within a housing;

(c)solder-mounting said electroplated second contact surface of said piezoelectric transducer element within said housing such that said piezoelectric transducer element is thereby coupled to said housing in a substantially conterminous fashion;

(d)installing a means for conducting electrical signals

between said electroplated first contact surface of said piezoelectric transducer element and the outside of said housing;

(e)closing said housing such that said piezoelectric transducer element is thereby substantially enclosed within said chamber of said housing; and

(f)configuring said housing on the outer surface of said duct such that said housing is at least partially conterminous with said outer surface of said duct and such that said piezoelectric transducer element is thereby coupled to said outer surface of said duct in a substantially conterminous fashion.

[c31] A fabrication process according to claim 30, wherein said piezoelectric transducer element is a ceramic crystal wafer.

[c32] A fabrication process according to claim 30, wherein each of said first metallic film layer and said second metallic film layer of said piezoelectric transducer element comprises at least one metal selected from the group consisting of gold, indium, and silver.

[c33] A fabrication process according to claim 30, wherein step (c) is performed with a solder comprising an indium alloy.

[c34] A fabrication process according to claim 30, wherein step (c) is performed at a soldering temperature less than a Curie temperature inherently associated with said piezoelectric transducer element.

[c35] A fabrication process according to claim 30, wherein step (c) is performed via an oven reflow process.

[c36] A fabrication process according to claim 30, wherein step (c) includes the step of artificially pressing said piezoelectric transducer element and said housing together for a predetermined period of time.

[c37] A fabrication process according to claim 30, wherein said housing comprises a plurality of pieces attached together and collectively suited for being situated on said outer surface of said duct.

[c38] A fabrication process according to claim 37, wherein step (f) includes the steps of:
(f1)electroplating at least part of an external surface of at least one of said pieces of said housing with an external metallic film layer comprising at least one metal selected from the group consisting of gold, indium, and silver; and
(f2)coupling at least part of said electroplated external surface to said outer surface of said duct in a substan-

tially conterminous fashion such that said piezoelectric transducer element is thereby coupled to said outer surface of said duct in a substantially conterminous fashion.

[c39] A fabrication process according to claim 38, wherein step (f2) includes the step of artificially pressing said electroplated external surface to said outer surface of said duct.

[c40] A process for fabricating an ultrasonic transducer assembly utile for helping monitor a fluid flowing through a duct, said fabrication process comprising the steps of:
(a)electroplating a first metallic film layer on a first contact surface of a piezoelectric transducer element and electroplating a second metallic film layer on an opposite second contact surface of said piezoelectric transducer element;
(b)configuring a housing on the outer surface of said duct such that said housing is at least partially conterminous with said outer surface of said duct;
(c)situating said piezoelectric transducer element in a chamber within said housing;
(d)solder-mounting said electroplated second contact surface of said piezoelectric transducer element within said housing such that said piezoelectric transducer element is thereby coupled to said outer surface of said duct in a substantially conterminous fashion;

(e)installing a means for conducting electrical signals between said electroplated first contact surface of said piezoelectric transducer element and the outside of said housing; and

(f)closing said housing such that said piezoelectric transducer element is thereby substantially enclosed within said chamber of said housing.